Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Physica A 383 (2007) 443–454
PHYSICA A
www.elsevier.com/locate/physa

Relaxation and phase space singularities in time series of human magnetoencephalograms as indicator of photosensitive epilepsy

R.M. Yulmetyev[a,b,*], P. Hänggi[c], D.G. Yulmetyeva[a,b], S. Shimojo[d], E.V. Khusaenova[a,b], K. Watanabe[e,f], J. Bhattacharya[g,h]

[a]*Department of Physics, Kazan State University, Kremlevskaya Street, 18 Kazan, Kazan 420008, Russia*
[b]*Department of Physics, Kazan State Pedagogical University, Mezhlauk Street, 1 Kazan, Kazan 420021, Russia*
[c]*Department of Physics, University of Augsburg, Universitätsstrasse 1, D 86135 Augsburg, Germany*
[d]*Division of Biology, CalTech, Pasadena, CA 91125, USA*
[e]*Research Group for Decision Making, Research Center for Advanced Science and Technology, University of Tokyo, Japan*
[f]*ERATO Shimojo Implicit Brain Function Project, Japan Science and Technology Agency, Japan*
[g]*Commission for Scientific Visualisation, Austrian Academy of Sciences, Tech Gate, Vienna A 1220, Austria*
[h]*Department of Psychology, Goldsmiths College, University of London, New Cross, London SE146NW, UK*

Received 26 February 2007; received in revised form 26 March 2007
Available online 27 April 2007

Abstract

To analyze the crucial role of fluctuation and relaxation effects for the function of the human brain we studied some statistical quantifiers that support the information characteristics of neuromagnetic brain responses (magnetoencephalogram, MEG). The signals to a flickering stimulus of different color combinations have been obtained from a group of control subjects which is then contrasted with those of a patient suffering photosensitive epilepsy (PSE). We found that the existence of the specific stratification of the phase clouds and the concomitant relaxation singularities of the corresponding nonequilibrium dynamics of the chaotic behavior of the signals in separate areas in a patient provide likely indicators for the zones which are responsible for the appearance of PSE.

Keywords: Discrete non-Markov stochastic processes; Relaxation and phase space singularities; Magnetoencephalograms; Human brain; Photosensitive epilepsy

1. Introduction

The study of dynamical time series is gaining ever increasing interest and is applied and used in diversified fields of natural sciences, technology, physiology, medicine and economics [1–8], to name only a few. The majority of natural systems can be considered dynamical systems, whose evolution can be studied by time

*Corresponding author. Department of Physics, Kazan State Pedagogical University, Mezhlauk Street, 1 Kazan, Kazan 420021, Russia. Tel.: +7 8432 925373; fax: +7 8432 924269.
E-mail address: rmy@theory.kazan-spu.ru (R.M. Yulmetyev).

0378-4371/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.physa.2007.04.046